Coping with the Weird Weather

BUILDING RESILIENCE INTO OUR CROPPING SYSTEMS
Contact Information

Jerry L. Hatfield
Laboratory Director
National Laboratory for Agriculture and the Environment
1015 N. University Blvd
Ames, Iowa 50011
515-294-5723
515-294-8125 (fax)
jerry.hatfield@ars.usda.gov
Changes in Our Climate

Global mean temperatures will continue to increase throughout the 21st century if CO₂ concentrations continue to increase and under the highest emission scenario would range from 2.6 to 4.8°C.

These temperatures changes will not be uniform across regions with increases over land surfaces being larger than over the oceans.

As the global temperatures increase there will be more hot extremes and fewer cold extremes at both daily and seasonal time scales.

Precipitation will increase with increases in global mean surface temperature and could increase 1 to 3% °C⁻¹; however, there will be substantial spatial variation in these changes.

Annual surface evaporation will increase as the temperatures increases; however, over land, evaporation will be linked to precipitation.
Key Messages- 2014 National Climate Assessment

Climate disruptions to agricultural production have increased in the past 40 years and are projected to increase over the next 25 years. By mid-century and beyond, these impacts will be increasingly negative on most crops and livestock.

Many agricultural regions will experience declines in crop and livestock production from increased stress due to weeds, diseases, insect pests, and other climate change induced stresses.

Current loss and degradation of critical agricultural soil and water assets due to increasing extremes in precipitation will continue to challenge both rainfed and irrigated agriculture unless innovative conservation methods are implemented.
Key Messages- 2014 National Climate Assessment

The rising incidence of weather extremes will have increasingly negative impacts on crop and livestock productivity because critical thresholds are already being exceeded.

Agriculture has been able to adapt to recent changes in climate; however, increased innovation will be needed to ensure the rate of adaptation of agriculture and the associated socioeconomic system can keep pace with climate change over the next 25 years.

Climate change effects on agriculture will have consequences for food security, both in the U.S. and globally, through changes in crop yields and food prices and effects on food processing, storage, transportation, and retailing. Adaptation measures can help delay and reduce some of these impacts.
Minnesota Precipitation: 1901-2010

Precipitation (in)

1900 1920 1940 1960 1980 2000

30 Year Mean  
Annual Mean  
Min Limit  
Max Limit
Annual Precipitation - *Minnesota*

- Linear (Annual): $y = 0.0244x - 21.533$, $R^2 = 0.055$
- Linear (Spring Annual): $y = 0.0077x - 5.5504$, $R^2 = 0.0147$
- Linear (Summer Annual): $y = 0.0045x + 1.0277$, $R^2 = 0.0052$
Projected Precipitation Change by Season
Minnesota Minimum Temperature: 1901-2010
Climate trends

Increasing precipitation

Shift in seasonality with more spring and more variable summer precipitation

Minimum temperatures are increasing more than maximum

Temperatures are increasing more in the winter than the summer
Rain into the soil

Assuming an average rate of crop water use during the grain-filling period for corn

Hudson, 1994
Variation of Water Holding Capacity within production fields
Soybean Production Field

Yield variability in a field comes from soils inability to supply water during grain-filling.
Good Soils = Good Yields

Soybean yields across Iowa, Kentucky, and Nebraska

Climate resilience is derived from good soils in rainfed agricultural systems
Maize County Yields

\[ Y = 436.096 + 478.149X, \quad r^2 = 0.58^{***} \]
Variation in NCCPI across the Midwest
Corn Production – Yield and Yield Gap

Mitchell County, Iowa Corn

Yield (bu/acre): 20 40 60 80 100 120 140 160 180 200 220
Yield Gap (bu/acre): -20 0 20 40 60 80 100
Soybean Production – Yield and Yield Gap

Mitchell County, Iowa Soybean

Year

Yield (bu/acre)


Yield Gap (bu/acre)


USDA
Yield Gaps

We have found that 20% of the yield loss occur 80% of the time due to short term stresses, e.g., we needed an 2 inches but only received 1 inch of rainfall for the week so the plant is under a moderate stress and not fulling its yield potential.
Stable Soil Systems

Low Biological Activity
- Low stability
- Slow infiltration, fast time to runoff
- Unstable microclimate
- Entrained material

High Biological Activity
- High stability
- High infiltration, delays runoff
- Stable microclimate
- Slow infiltration, fast time to runoff
- High infiltration, delays runoff
Soil Aggradation Climb

Visible Outcomes

- Improved Water Availability
- Improved Soil Structure
- Improved Nutrient Cycling
- Organic Matter Turnover
- Biological Activity

Invisible and dynamic process
Role of residue on the soil surface
Benefits of Using Cover Crops

- Reduced erosion
- Reduced nitrate leaching
- Reduced phosphorus losses
- Increased soil organic matter
- Improved weed control
- Support and maintain soil organisms
- Improve soil structure – especially no-till
- Grazing and forage potential
- Recycling manure nutrients
The “living soil”, a biological system.

Mammals - gophers, moles, mice, groundhogs
Earthworms - night crawlers, garden worms
Insects and mollusks - ants, beetles, centipedes, snails, slugs
Microfauna - nematodes, protozoa, rotifers≈
Microflora - fungi, yeast, molds, mychorhiza
Actinomycetes - smaller than fungi, act like bacteria
Bacteria - autotrophs, heterotrophs, rhizobia, nitrobacter
Algae - green, blue-green

Earthworms, insects and rodents are “nature’s plow” and the most visible components of the “living soil” team. They work in tandem with other soil fauna, soil microorganisms and fungi to contribute to aeration and nutrient cycling as part of a “soil factory” team effort.
Evolution of a continuous no till systems: 4 phases

**Initial**
- Rebuild aggregates
- Low OM
- Low crop residues
- Reestablish microbial biomass
- > N

0-5

**Transition**
- Increase soil density
- Start increasing crop residue
- Start increasing soil OM
- Start increasing P
- Immobilize N >= Minimum

5-10

**Consolidation**
- High Crop Residue
- High C
- > CEC
- > H2O
- Immobilize N < Min.
- > Nutrient Cycling

10-20

**Maintenance**
- High accum. of crop residue
- Continuous N and C flux
- Very high C
- > H2O
- High nutrient cycling
- Less N & P use

>20

Time (years)

Source: Sa, 2004
## Carbon Balance in Corn-Soybean Fields 2000-2016

<table>
<thead>
<tr>
<th>Rates (Mg C ha(^{-1}) yr(^{-1}))</th>
<th>Field</th>
<th>Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔTC</td>
<td>-1.52 ± 0.78</td>
<td>-1.54 ± 0.76</td>
</tr>
<tr>
<td>C budget</td>
<td>-1.70 ± 0.01</td>
<td>-1.72 ± 0.02</td>
</tr>
</tbody>
</table>
Spatial variation- dry mean weight diameter

Sampling in 2016 was prior to implementing cover crop and no-till, change in the upper 15 cm in the 2017 samples
Spatial variation – Microbial biomass
History of the Coles South Field

1930’s

1950’s

1960’s

1980’s

1990’s

2015
What do we know

Our weather is becoming more variable

Efficient crop production is dependent upon good weather and a good soil

We can manage the soil to increase climate resilience by increasing water availability and nutrient cycling

Enhancement is soil is only possible by enhancing and maintaining the soil biological system
Overcoming Variability for Maximum Yield

\[ G \times E \times M \]

- Genetics
- Environment
- Management

Yield Gap
Maximum Potential Yield

Genetics
Environment
Management

USDA